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**Transmission of X-ray Polarization Through Glass Capillary Fibers**

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Beamline(s): X14A

**Introduction**: In recent years, glass capillary fibers have proven to be increasingly useful for transporting, focusing and collimating x-rays from one to over 50 keV.[1] Of order $10^3$ capillaries 10 microns in diameter can be enclosed in a single fiber less than one mm across. The x-rays are confined to the air-filled hollow regions in each capillary by a hundred or more glancing angle collisions within a critical angle $\vartheta_c \approx 32/E(keV)$. The question to be answered was whether,despite the changing ray directions, the multiply-scattered rays reflected by the glass walls of either straight or bent fibers would permit an initial x-ray polarization to be retained on transmission, The result could be of use with focusing optics for background reduction in x-ray fluorescence spectroscopy.[2] The experiments were also intended to quantify the effect of reflection number on polarization transmission.

**Methods and Materials**: A polarimeter, which employed Rayleigh-Thompson scattering was used to measure the residual polarization of x-rays emerging from the fiber. An assembly consisting of fiber, carbon-foil scatterer, and proportional counter could be rotated through 360$^o$ around the beam direction as axis. The foil scatters the emergent x-rays by 90$^o$ into the counter. Once a fiber is inserted into the apparatus, it can be bent to deflect x-rays while its straight entrance section remains along the beam axis. The fiber and the line joining the centers of the foil and counter define a plane, which makes a specified angle (phi) with the synchrotron beam electric field vector. If the emergent x-rays were one hundred per cent polarized, as the assembly is rotated, the counting rate should vary as cos (phi); in contrast, for a completely depolarized emergent beam the counting rate should be uniform. Intermediate polarizations add a constant term to the cosine dependence.

Labeling $I_{max}$ and $I_{min}$ as, respectively, the maximum and minimum counting rates in an angular scan, the emergent polarization is defined as:

$$P = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

The assembly was set up and aligned using the Huber diffractometer. A technique was developed to hold the fibers on the beam-axis while confining the beam to the fiber without introducing stress. Nevertheless, it proved desirable to realign the fiber at each angle setting during the complete 360$^o$ scan. The beam energy was 8 keV and the fiber 16 cm long. The emergent P was measured for 1) for the direct beam, 2) after transmission through a straight fiber, 3) after transmission through a bent fiber.

**Results:** The 360$^o$ angular scans were clearly sinusoidal for parts 1) and 2) above, permitting values of P to be extracted for a 16 cm long fiber and proving that the beam retained a high degree of polarization for a straight fiber, and maintained P to a slightly lesser extent for a bent fiber. Values of P for the direct beam were, respectively, 0.85 ±0.01 and 0.73±0.02. For a fiber bent 1 cm over a 10 cm length, the count rate at 180$^o$ exceeded that at 0$^o$ and 360$^o$ by one-third, which was found to be due to a gravitational effect on the fiber. However, there was residual polarization P slightly less than 0.7. For a 1.6 cm in 10 cm deflection, the peaks and valleys were more erratic; nevertheless, there was clear evidence of sinusoidal behavior indicating significant residual polarization. It was later found that the end of the fiber moved off the carbon foil during rotation.

**Conclusions:** The initial synchrotron beam polarization is transmitted with little attenuation through a 16 cm long straight capillary fiber as used in focusing and capillary optics. The degree of polarization transmitted decreases slowly as the fiber undergoes increasing deflection. The measurements should be improved considerably by maintaining the entire fiber fixed, and measuring the emergent polarization by rotating a just the (larger} carbon foil and the counter around the end of the fiber using a rotating stage. This modification has now been constructed, and a second run at NSLS is imminent. The emphasis will again be on relating transmission to the number of wall collisions.

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**References**:

[1] M. A. Kumakhov, "Channeling of Photons and New X-ray Optics," Nucl. Instr. and Meth. B48, p283 (1990).

[2] R. W. Ryan and J. D. Zahn in "Polarized Beam X-Ray Fluorescence," Section 10 in *Handbook of X-Ray Spectrometry,* eds. Rene' E. Van Grieken and Andrej A. Markowicz (Marcel Dekker, New York 1990).